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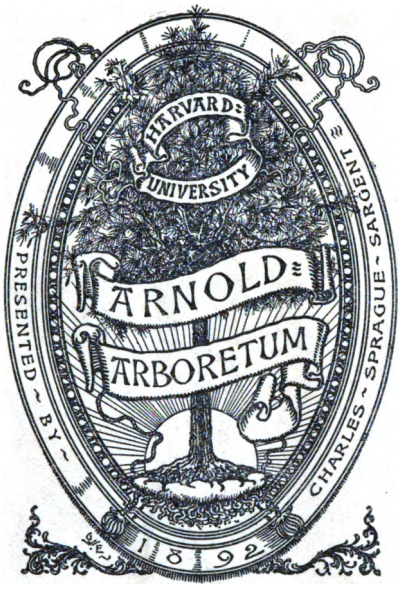

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REPORTS, ETC.

ON

Dr. Boucherie's Patent

FOR

PRESERVING TIMBER FROM DECAY.

THE PERMANENT WAY COMPANY,

26, GREAT GEORGE STREET, WESTMINSTER.

1856.

LONDON:
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DESCRIPTION

OF

DR. BOUCHERIE'S PATENT PROCESS

FOR

Preserving Timber from Decay.

THE PERMANENT WAY COMPANY,

26, GREAT GEORGE STREET, WESTMINSTER.

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DESCRIPTION

OF

DR. BOUCHERIE'S PATENT PROCESS

FOR

Preserving Timber from Decay.

THIS patent is for an important improvement in the process of preparing timber, so as to preserve it from decay. It is the invention of the eminent French chemist Dr. Boucherie, who has devoted nearly twenty years in bringing it to perfection. It is regarded as of the highest importance, being the only mode yet discovered by which the durability of woods liable to decay can be effectually secured. The system of Dr. Boucherie accomplishes two objects: first, that of expelling the sap; and secondly, filling the pores of the timber with a preservative solution.

The mode hitherto adopted to impregnate trees has been by saturation only, assisted sometimes by great pressure, and by previously submitting the timber in cylinders to a vacuum or to heat.

Dr. Boucherie's process differs entirely; inasmuch as he applies a moderate pressure, and to one end only of the sap-tubes of the tree; the effect of which is to expel the sap by the preserving liquor, which takes its place.

By the processes hitherto used, the sap (the fermentation of which is admitted to be the cause of decay) is allowed to remain in the tree; in the Boucherie process the sap is expelled, and the tubes are thoroughly cleansed from the fermenting matter.

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The tubular structure of trees has been long known, but it has not been long known that no connection exists between the tubes laterally; and this Dr. Boucherie has shown by the interesting experiment of shutting off certain tubes at the end of the tree, leaving those exposed which form a word; which word, or name, by applying a colouring liquor, can be driven from one end of a tree to the other; so that wherever the tree is cut, the name appears distinctly in coloured letters.*

This experiment is interesting, not only in a scientific point of view, but it shows that none of the processes hitherto used can force any preserving liquor into a tree without a degree of pressure, which must injure the fibre of the wood and destroy its strength and use for many purposes.

The advantages which would result from expelling the sap and replacing it with an antiseptic fluid have been long known; and the idea of effecting it by applying the fluid under pressure at the end of a piece of timber is not new, having been suggested and patented many years ago by Mr. Bethel. But the means then used did not accomplish the object in such a manner as to admit of its commercial application. Hence the more expensive process of creosoting has been adopted; where the timber is totally immersed in the oil under pressure, which does not permit the sap to escape.

By the old process of violent pressure, the preserving liquor is forced at right angles to the tubes through the woody fibre of the tree, injuring its strength as well as its capability to resist in railway-sleepers the wear of the chairs, consuming at the same time an unnecessary amount of the preserving liquor, without (whatever pressure may be applied) thoroughly impregnating the timber, while with Dr. Boucherie's, $\frac{1}{6}$ or $\frac{1}{8}$ of the force only is necessary; and the portion only requiring the preservative, viz. the soft matter between the rings, is impregnated, the woody fibre remaining unbroken and undisturbed.

Another important advantage in Dr. Boucherie's process is

* Professor Faraday's name was forced through an oak-tree in this manner by Dr. Boucherie, a slip of which may be seen at the office of the Permanent Way Company, 26, Great George Street, Westminster.

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derived from the simplicity and small cost of the apparatus, which, for small quantities, will not exceed £10 or £15, and for a railway of 200 miles under £50.

The small expense of the apparatus will enable the process of preserving timber to be applied in cases where it has not hitherto been available. It will be economy for all proprietors of land of any extent, to preserve the timber used on their estates for fencing, farm-buildings, gate-posts, &c.; an advantage that has hitherto been denied them, as the impregnation of the timber (however effective the material may be) is entirely useless applied under great pressure, which requires expensive cylinders and steam-apparatus, involving an expenditure of from £500 to £1,000.

As stated before, the tubular structure of trees has of course long been known, and the idea of impregnating the tree by means of the sap-tubes has long engaged the attention of scientific men; but it has fallen to the lot of Dr. Boucherie, with a perseverance rarely excelled, to bring about its practical application, and with a degree of entire success, as will be seen by the annexed printed French official Reports,* the first of which was made by order of the French Government in the year 1850, by a commission composed of the following distinguished engineers of the Ponts-et-Chaussées:—

M. Avril,
,, Didion,
,, Mary.

The second in the year 1852, addressed to the French Minister of Marine, by a naval commission composed of the principal officers of the Génie, as follows:—

M. Leroux, Inspecteur-général du Génie maritime,
,, Sochet, Ingénieur de la Marine,
,, Dupony, Capitaine de Frégate.

The third in the year 1856, being an extract from the official jury Report, by order of the French Government, of the Exposition Universelle of the year 1855, in which it will be seen that the

* These Reports are published separately, and may be had on application to the Permanent Way Company.

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distinguished honour of one of the large gold medals was awarded to Dr. Boucherie, of which only four were conferred in all.

When the timber is under operation, the sap runs out from the ends in a clear stream, showing the amazing quantity of this fluid which it contains; in fact, the preserving fluid will traverse a tree 12 feet in length with less pressure than is required to force it laterally through a plank three-quarters of an inch in thickness. As the sap is forced out, the preservative fluid follows it, and its presence at the ends of the wood is ascertained by a chemical test. Thus the sap and fermenting juices are completely expelled, and the timber impregnated throughout its length with the preserving fluid.

Important advantages must of necessity arise from the general employment of the process. It may be applied successfully to cheap wood of quick growth, such as Scotch fir, beech, elm, and other home-grown timber; and it is not necessary that the wood should be dried or seasoned before being prepared, but on the contrary, the operation is better effected immediately after the tree has been cut down. There is a great saving in first cost, as compared with Baltic timber creosoted; while it is rendered as durable as heart of oak, as may be seen in the Reports above referred to.* Previous to these Reports, a favourable and important one was made in the year 1841, by a committee of the French Academy of Science, M. Arago being chairman, upon the occasion of a pamphlet on the subject by Dr. Boucherie being read before that distinguished body, and which was subsequently ordered to be inserted in the *Recueil des Savants Etrangers*, and copies to be forwarded to the Ministers of Agriculture, Commerce, Public Works, Marine, Finance, and War,—a complete copy of which we regret has not been furnished us at the time of going to press, but which will be in our possession shortly.

The method of application which up to this date has been found to be the most economical and practicable we will now proceed to describe. Soon after the tree is felled, a saw-cut

* The total absence of smell is another advantage in wood thus prepared, particularly in railway-stations, tunnels, and other confined places.

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is made in the centre, through about $\frac{9}{10}$ of its section. The tree is then slightly raised by a lever or wedge at its centre, and the saw-cut is then partially opened, as shown in Fig. 1.

Fig. 1.

A piece of string is then placed round the saw-cut, close to the outer circumference of the tree, the support is then withdrawn, and the saw-cut closes on the string, thereby making a water-tight joint. An auger-hole is then bored obliquely into the saw-cut in the direction shown at Fig. 2, *a a*,—a wooden

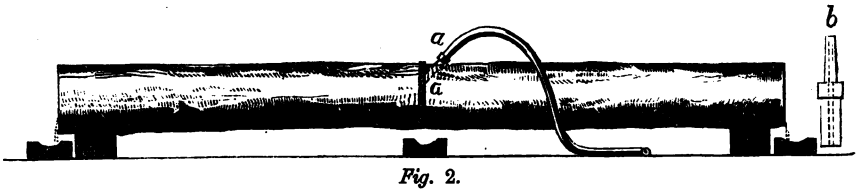

Fig. 2.

tube, *b*, is then driven into the hole, the conical end of which is attached to a flexible pipe, which is in connection with a cistern or reservoir, at an elevation of from 30 to 40 feet above the tree intended to be preserved. The method of applying the process on a large scale will be made obvious by a glance at the accompanying engraving.

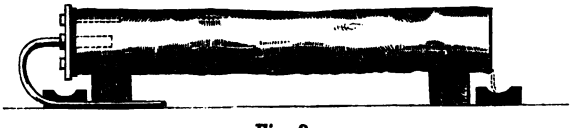

Fig. 3.

When it is necessary to prepare timber in long lengths, a cap is placed on the end of the tree, by screws or dogs, as shown in Fig. 3. Dr. Boucherie has found that the most efficacious

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solution is composed of sulphate of copper and water, mixed in the proportion of 1 by weight of sulphate of copper to 100 of water. The strength is easily ascertained by any intelligent workman by an hydrometer. The specific gravity of water at 60° of Fahrenheit being 1,000, if 1 per cent. of sulphate of copper is added, the specific gravity will be 1,006 nearly.

It can be readily ascertained when the pressure has been on sufficiently long as to have expelled the sap, and been replaced by the solution by means of prussiate of potash. If a piece of this crystal is rubbed on the timber when it is in a damp state, it will leave a deep red-brown mark, showing that the timber is sufficiently impregnated with the copper. The sap containing at most a 1000th part of organic matter in solution, there is no inconvenience in employing it as a solvent. It is even preferable to many waters containing lime, which decompose a much greater proportion of sulphate of copper. Therefore, troughs are placed under the end of the trees, to catch the sap and waste solution, and conducted to a reservoir to be pumped up and mixed again with copper to the proper strength. The best trees for the operation are the least costly; as for instance, beech, birch, Scotch fir, alder, elm, poplar, &c.* The sooner the trees are prepared after being felled the better; consequently, the nearer they are prepared to the place where they are grown, the more advantageous it will be found. Trees felled any time from November to May, may be prepared in May; but if they are cut down in May, or any month from May to the end of November, they ought to be prepared within three weeks from the time of being felled.

It has been found, in the preparation of vast quantities of timber for the French navy and railways by this system, that the time necessary for the operation depends on the length of the tree and the description of timber. Trees of forty feet in length are being prepared at Fontainebleau for the French navy, which require from eight to ten days before they are

* A table of the results of experiments in the preparation of these trees by this process, made at Derby, in May, 1856, is published, and may be had, post-free, on application to the Permanent Way Company.

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sufficiently impregnated; but for lengths of nine feet, twenty-four hours are found to be quite sufficient.

The expense of the process will of course vary with the price of copper, cost of labour, and carriage. The cost of copper necessary for the impregnation of a single railway-sleeper has been found in France to be about 5*d*. It will be readily seen that the cost of the necessary apparatus and labour will be very small.

The success of the system in France has been most complete. Scientific and practical men vie with each other in their common approbation of the invention, as will be seen by the annexed Reports. The Government have used, and are having prepared, great quantities of timber for the navy. The great French railways are also having their sleepers thus prepared. The Chemin de Fer du Nord alone, in the year 1846, laid down 80,000 beech and birch sleepers; and in 1853, upon examination, these were found in so complete a state of preservation, that this Company immediately ordered a further supply of 300,000. Again, in the year 1856, many of the sleepers laid in 1846 were opened out, and all of them found to be as sound as when first laid down.

In the year 1846 the French Government substituted white pine telegraph-posts, prepared by this process, for the usual oak posts, for the telegraphic wires on the Rouen line; and they are at the present time in as perfect a condition as when first erected.

It is well known that timber decays most rapidly at and near the surface of the earth, or "between wind and water;" but these posts exhibit no such symptom, proving that the preservative process is efficacious both in dry and damp situations. Mr. Alexander, inspector of telegraphic lines in France, officially reported the costs of the two kinds of posts employed on that line, as follows:—

Prepared Pine Telegraph Posts.	Feet.		Unprepared Oak Telegraph Posts.
Ordinary posts	5½	(4s. 5d.) agst.	16 fr. (12s. 9d.)
Winding posts	9	(7s. 3d.) „	40 fr. (£1.12s.)
Crossing posts	16	(12s. 0d.) „	70 fr. (£2.16s.)

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The following letter on the subject is from the administration of telegraphic lines in France:—

"*Paris, August* 14, 1855.

"SIR,—All the telegraphic posts in the French empire have been prepared by your process.

"The administration had 200,000 on the 1st of January last, and since that time have caused 32,000 additional posts to be prepared.

"The preservation of the posts thus injected with sulphate of copper is rendered complete, although the first were prepared and laid down in the year 1846.

"It is with pleasure, Doctor, that I am enabled to give you this information, in order that you may communicate it to the members of the jury of the Universal Exposition.

"I am, Doctor, &c.

(Signed) "H. DE VOUGY,

"Chief Administrator of Telegraphic Lines, Minister of the Interior.

"To Dr. Boucherie."

In the South of France large quantities of vine-sticks, prepared by this process, are made use of; and it is obvious that it may be applied with equal advantage to hop-poles.

It would be difficult to enumerate the classes it will benefit, and the uses to which it may be applied. Railway companies, ship-builders, telegraph companies, landowners, coalowners, for their pit timber, will alike benefit by it. Post and rail fencing, field-gates, wood farm-buildings, will last many additional years.

Mr. Robert Stephenson, the President of the Institution of Civil Engineers, in his inaugural address, adverts to the great consumption of sleepers by decay, and estimates it at 2,600,000 sleepers per annum; probably the average cost of these may be taken at 4s. 6d. each, or £585,000. If we were to take the resistance of the prepared timber to decay as the only basis of

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calculation, a large proportion of this sum would be saved; but there are mechanical causes of destruction to be estimated, and we may reasonably assume that the duration of the sleeper is doubled; making a saving of nearly £300,000 per annum to the railway interest.

The Permanent Way Company, 26, Great George Street, Westminster, beg to announce that Dr. Boucherie has given them the sole authority to grant licenses for the use of his patent for preserving timber, applications for the terms of which may be made to William Howden, the Secretary.

Printed by Day & Son, Lithographers to the Queen, Gate Street, Lincoln's-inn Fields, London.

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EXTRACT FROM THE "ANNALES DES PONTS-ET-CHAUSSÉES,"
FOR MARCH AND APRIL, 1850.

REPORT

OF THE

RESULTS OF EXPERIMENTS

MADE

BY M. LE DOCTEUR BOUCHERIE

ON HIS

METHOD OF PRESERVING TIMBER,

BY A COMMISSION, COMPOSED OF

MM. AVRIL, DIDION, & MARY,

1850.

THE PERMANENT WAY COMPANY,
26, GREAT GEORGE STREET, WESTMINSTER.

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EXTRACT FROM THE "ANNALES DES PONTS-ET-CHAUSSÉES,"
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REPORT

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Method of Preserving Timber,

BY A COMMISSION COMPOSED OF MM. AVRIL, DIDION, & MARY.

THE process invented by M. le Docteur Boucherie for preserving wood by the injection of a liquid calculated to ensure its preservation, has been, since 1839, the subject of various communications to the Académie des Sciences, and of several Reports favourable to his invention. One of these Reports, drawn up by M. Emmery, Inspecteur-Divisionnaire des Ponts-et-Chaussées, was inserted in vol. xviii. of the "Annales" (first series), page 363, shortly after the discovery of M. le Docteur Boucherie's plan, and before sufficient information had been obtained to determine either the choice of the preserving material, or the best course of proceeding to be adopted in order to force the liquid into the inner substance of the wood. On this account, notwithstanding the well-deserved approbation which the invention received, no important application of it took place previous to 1846.

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If we inquire what circumstances have retarded the development of so useful an invention, we find them comprised under two principal heads; viz. — the hesitation felt with respect to the efficacy of the solutions to be employed in ensuring the preservation of the timber; and the difficulty in causing those solutions to penetrate into the timber by a process both simple and economical.

These causes of delay exist no longer. Since 1846, M. le Docteur Boucherie has employed a very simple method of injection, and a solution, whose preservative effects have been fully established by seven years' experience; and have since that time appeared so satisfactory to the Northern Railway Company of France, as to decide them upon entrusting to M. le Docteur Boucherie the supply of 60,000 sleepers for the branch-line to St. Quentin.

It was with a view to verify the results obtained under these new conditions, that we were appointed by the "Conseil-Général des Ponts-et-Chaussées," with the approbation of the Minister of Public Works, to examine the actual state of this important industrial operation, which is calculated to exercise so great an influence on the preservation of every description of wood-work, and more particularly of railway-sleepers.

In order to accomplish our task, we felt it to be our duty to examine carefully the numerous experiments made by M. le Docteur Boucherie on woods of various kinds, and on all the substances which seemed capable of exercising a preservative influence. It was to the selection to be made amongst these substances that he directed his investigations, after having satisfied himself as to the inefficacy of those to which he at first gave the preference.

In order to discover more rapidly the material which should possess the preserving quality most effectually, M. le Docteur Boucherie did not employ, for the purposes of his experiments, timber whose durability in its natural state is very considerable—but cotton cloth, which, in consequence of its slight texture, decays much more rapidly. He placed before us a number of samples of this cloth, impregnated with various

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solutions, the effects of which are indicated in the following table:—

Description of Solutions.	Duration of Experiments.	Effects produced on the Cloth.
	1839.	
None	Jan. 12 to March 22	Much altered, but not thoroughly affected.
Milk	Feb. 5 to April 4	Almost in shreds.
Deutochloride of Mercury, 10 per cent.	Jan. 12 to March 21	Well preserved.
Do. 5 per cent.	do. do.	Spots, holes, texture injured.
Sulphate of Zinc, 10 per cent.	Jan. 12 to March 21	Appreciable alteration.
Do. do. 5 per cent.	do. do.	Completely rotten.
Acetate of Lead, 10 per cent.	Feb. 1 to March 22	Altered in all parts.
Do. do. 5 per cent.	do. do.	Completely rotten.
Sulphate of Iron, 10 per cent.	Jan. 18 to March 22	do. do.
Oil and Tallow	Feb. 1 to April 6	Numerous blackish spots.
Linseed Oil	do. do.	Alteration commenced.
Rosin	do. do.	Less altered than the foregoing.
Sulphate of Copper, 10 per cent.	Jan. 12 to March 28	Completely preserved.
Do. 5 per cent.	do. do.	do. do.
Do. $2\frac{1}{2}$ per cent.	do. do.	do. do.
Do. $1\frac{1}{4}$ per cent.	do. do.	do. do.
Do. $\frac{6}{1000}$	do. do.	do. do.
Do. $\frac{1.5}{1000}$	do. do.	Some spots observed.

Similar experiments have been made on wood by M. le Docteur Boucherie, both at his own establishment and in the forest of Compiègne. Those at Paris were made on pieces of wood 5 in. thick, 1 foot wide, and 1 ft. 4 in. long. To render these experiments more conclusive, the pieces of wood were impregnated for one-half of their length by hollowing out at one end a small cup, into which the liquid was poured. The

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pieces of wood thus prepared were buried (on end) near the surface of the ground, and left in that state up to the present.

We examined several of them, and satisfied ourselves that the solutions acted on the timber in the same manner as on the cotton cloth:—thus, the parts penetrated by the sulphate of copper were entirely preserved, while those parts which were left in their natural state were completely rotten. We shall not enter into further details respecting these experiments at Paris, because they are less important and less authentic than those made at Compiègne; and moreover, the results were the same.

The experiments at Compiègne were made on woods of different kinds and dimensions;—the pieces which formed the subjects of them were placed, some in the pheasantry, and the others on the banks of the Oise, at the landing-place of La Croix, Saint-Ouen.

In order to examine the condition of these woods, on the 23rd July, we repaired to the inclosure of the pheasantry, situated in the forest of Compiègne, where in 1842 M. le Docteur Boucherie made his first experiments, in preserving on a large scale, on some trees newly felled. At that time he had not yet discovered a practical method of forcing the liquid into the substance of the timber; when he had occasion to impregnate any piece, he placed a leaden cap on one end of it, and fixed it with a number of nails very closely driven; then, by means of a pipe, soldered on the cap, he introduced the liquid between the lead and the end of the timber, subjecting it to a pressure at his own discretion, but which never exceeded about one mètre (or about 3 ft. $3\frac{1}{3}$ in. English).

He employed for these injections the sulphates of iron and of soda, pyrolignite of iron, pyroligneous acid more or less concentrated, chloride of calcium, chloride of mercury, pyrolignite of lead, and sulphate of copper. The pieces of wood thus prepared were immediately placed in excavations formed in a sandy soil, and buried close to the surface of the ground around them.

The following table shows the results of our observations on

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all the blocks we found, and which were under test during a period of seven years, as appears by various certificates signed by several public officers of Compiègne, who were present at our visit, and at all the examinations made at different times since the impregnation.

Number and Nature of the Pieces of Wood.	Nature of the Liquid injected.	Condition of the Wood.
1 block of Beech	This block was buried in its natural state, immediately after being felled.	Entirely rotten.
Do. do. do.	Sulphate of Soda	Some parts preserved, others decayed.
Do. do. do.	Sulphate of Soda	Do. do.
Do. do. do.	Pyrolignite of Iron	Entirely rotten.
Do. do. do.	Concentrated Pyroligneous Acid of Iron	Tolerably well preserved; smells of Creosote.
5 blocks of Beech	Do. less concentrated	Completely decayed; no smell of the acid.
1 block of Hornbeam	Do. do. do.	Do. do. do.
1 block of Beech	Chloride of Calcium	Preserved at one end, decayed at the other.
Do. do. do.	Do. do.	Preserved where exposed to the air; decayed beneath the surface of the ground.
Do. do. do.	Chloride of Mercury	Do. do. do.
Do. do. do.	Pyrolignite of Lead	Entirely decayed.
5 blocks of Beech	Sulphate of Copper	Perfectly preserved. Two blocks, sawn across, presented the central portion affected with the dry-rot for about one inch of the diameter; the solution had not penetrated into this central part; the bark was equally well preserved, as well as the lichens which adhered to it.

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From the Pheasantry we proceeded to the Port de la Croix, Saint-Ouen, on the left bank of the Oise, where we saw several logs of hornbeam in the bark, from 23 to 26 feet long, impregnated with sulphate of copper; and others, of the same dimensions, which had been left in their natural state.

The first, on being tried with the axe, proved to be in a state of perfect preservation, even at the surface; whilst the latter, being affected with the dry-rot, allowed the tool to sink deeply into their substance.

In addition to this, we caused two trees, of about 12 in. diameter, to be sawn across; one was impregnated with the sulphate of copper, the other in its natural state. The first was perfectly well preserved, except in the centre, where we found a small circular spot of dry-rot, not penetrated by the liquid. The second, that is to say the hornbeam in its natural state, was decayed, excepting about a twentieth part of its section, in certain portions radiating from the centre, in different directions.

On returning from our examination at Compiègne, we inspected a number of posts for supporting the wires of the Electric Telegraph on the Northern Railway, and found them in a state of perfect preservation. M. Maniel, engineer in charge of the maintenance of the line, showed us one of these posts, which was sunk in the Ouse in 1848; this post had a splinter partially detached by a stroke of an axe at the water's edge. The splinter, which had been recently separated from the post, had its edges perfectly sharp, and offered as great resistance as it would have done at the time when the tree was felled. M. Alphonse Foy, superintendent of the telegraph, assured us that the fir employed on the Northern line had remained in perfect condition until the present day; whereas the oak posts on the Rouen line had already undergone a very perceptible alteration.

These facts can leave no doubt of the efficacy of the sulphate of copper in preserving woods, into the texture of which it is possible to force the liquid. But in order to render this discovery really useful, it is necessary that we should possess an easy and economical method of driving the solution of that salt of

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copper into the substance of the wood. It therefore became our duty to examine the means actually employed for that purpose.

M. le Docteur Boucherie, far from making a secret of his process of impregnation, gave us all the details we could desire as to the arrangements made for the preparation of the sleepers for the railway from Creil to Compiègne, and the apparatus he has since invented for forcing the sulphate of copper into heavy timbers, such as piles, &c., which it is desired to preserve from decay.

For the preparation of the sleepers for the St. Quentin Railway, M. le Docteur Boucherie employed a process so simple and practicable, that the problem may be considered as solved with respect to timber which is to be worked up in short lengths. It may be described as follows :—

Logs of beech or hornbeam, large enough to make from two to four sleepers, being laid horizontally on three wedges, one in the middle, the other two near the ends, a saw-cut is made in the middle of the tree, penetrating about 9-10ths of its section. The log being thus prepared, the wedge which had been placed under the centre of its length is driven so as to lift the tree and open the saw-cut, and allow an unravelled cord to be inserted round the outer circumferance of the tree, as far as the part remaining uncut, and the two ends of the cord are then taken up and crossed at the upper part of the cut, care being taken to keep it at a very small distance all round from the outer surface of the log. The wedge placed under the centre of the log is then withdrawn, so as to allow the parts of the tree to come together again, and the joint, closing on the cord arranged as just described, will be caulked tight round its whole circumference.

If, now, we imagine an auger-hole pierced obliquely from the upper side of the log to the saw-cut, and a nozzle of wood or metal introduced therein, to which is fixed a pipe of water-proof cloth, fitted at the other end to the bottom of a shoot arranged above the works, it is easy to perceive that the liquid will be conducted into the space formed by the saw-cut, and from thence into the two adjoining portions of the log.

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Other channels, placed under the ends of the logs ranged in parallel lines, and under the saw-cuts, received the liquid which had percolated through them, or which had escaped through imperfectly-made joints, and conducted it back by a fall, in a contrary direction to that of the shoot above, to a tank fixed under the head of that shoot; so that by means of a pump fixed in the tank the liquid was raised to be again used, care being taken to maintain the degree of concentration requisite for the preservation of the timber.

In order to stop the flow of the liquid into a log whose preparation was completed, the pipe was compressed by a piece of wood split at one end, the two parts of which were drawn together and tied with twine; so that, without losing the liquid or stopping the process in other parts of the works, the prepared log could be removed and replaced with another.

M. le Docteur Boucherie has applied the process we have just described to the preparation of 23,000 sleepers of beech and hornbeam, employed in 1847 on that portion of the St. Quentin line extending from Creil to Compiègne; but although the results obtained were favourable, he could not, for want of time, prepare the whole quantity for which he had contracted.

When in 1849 he was commissioned to furnish a fresh supply for the section of the line between Chauny and St. Quentin, he endeavoured to improve this process, and succeeded in so doing by substituting in the place of the upper shoot which supplied the liquid a closed pipe, buried in the ground underneath the pieces of timber, and supplied from a tank, at an elevation sufficient to keep up the required pressure, and conduct the liquid into the saw-cuts by means of flexible pipes of cloth or of India-rubber attached to the supply-pipe. Unfortunately the speculations made in beech, in consequence of M. le Docteur Boucherie's success, precluded him from purchasing that kind of timber; and he was obliged to furnish sleepers of oak, although at a less price than those of beech and hornbeam, impregnated with the sulphate of copper.

The suppression of the shoot, by rendering the space above

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the sleepers free, would have permitted the more easy and rapid arrangement of the logs in their places, by means of a crane working over the truck employed to remove them, after the saw-cut had been made and the cord-joint prepared; so that, in order to make the joint and commence the impregnation, nothing further would be necessary than to lay them down on the blocks at their ends.

The process we have just described could not be applied to the impregnation of trees intended to be preserved entire; and until very lately M. le Docteur Boucherie was compelled to have recourse to the leaden caps, the use of which we have before described. Being led to seek a more practicable method, by the necessity of preparing a great number of trees, he succeeded at length in discovering processes of impregnation, which seemed to leave nothing to be desired, but which differed according to the size of the timber.

In operating on large trees, which we will suppose to be cut square at the base, he makes a saw-cut some few inches from the bottom, but taking care, as in the case of the sleepers, to reserve about one-tenth part of the wood. He drives an auger-hole, in an oblique direction from the surface of the log, into the saw-cut, which he fills with a piece of cord. Having made these arrangements, he applies to the base of the trunk a strong wooden plate, covered with a layer of well-worked plastic clay; and fixes this plate by means of a screw, which passes through its centre, and penetrates a few inches into the log beyond the saw-cut. The pressure acts upon the cord, and by stanching the joint, prevents the liquid introduced into the saw-cut from escaping by the large end of the tree. Each trunk is operated on separately.

When M. le Docteur Boucherie was called on to prepare some thousands of trees, either for posts for fencing or any other purpose, it became necessary to operate upon a great number at the same time, and consequently to discover some other method. This is as follows:—

At the same height as the benches on which were laid the timbers to be impregnated, he fixed a wooden case, about 6 in.

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wide and 10 in. deep, hermetically closed and jointed, or else a wooden pipe. The sides of this case were perforated with round holes, rather smaller in diameter than the trees to be operated on. The rings, which were cut out in the formation of these holes, were removed with care by means of a centre-bit, and laid by; so that, when the hole had been somewhat widened out on the outer side with a rasp, the ring cut from it might be used (after the introduction of the end of an india-rubber pipe of from 4 in. to 6 in. diameter), for the purpose of fixing the pipe to the case, by forcing it into the interior of the flexible pipe, and securing it in its place by compressing the elastic substance of the tube between the edge of the hole and the circumference of the ring, which was perforated with a small hole in the centre.

Thus as many india-rubber pipes were fitted to the sides of the case as there were pieces of timber to be prepared. These pieces were stripped of their bark, and rounded at the large end by a tool, with which one or two annular indentations of slight depth were made near the end. Each piece thus prepared was inserted into one of the pipes; and then, after being blocked up on the stage, the pipe was secured with a roll of twine, which the workmen took care to bind over the indentations.

When all the trunks were thus connected with the case by means of the india-rubber pipes, the case was filled with the preserving liquid, and the requisite pressure given by means of an upper cistern kept constantly supplied, and to which the liquid received in the channels placed under the ends of the trunks was raised.

This process, which was very simple, has been recently brought to yet greater perfection. Instead of fixing the pipes directly to the case, M. le Docteur Boucherie interposed between them a small pipe, some 2 or 3 feet long and about $\frac{3}{8}$ diameter, terminated by small ferules of wood or of copper. One of these ferules was fixed in the case, and the other in a disc of wood, on which was fastened the larger pipe intended to inclose the ends of the pieces of timber. By this means the case could be kept constantly full, and the process continue uninterruptedly,

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by stopping the flow of the liquid to the separate pieces, by compressing the supply-tube, as before described.

The question of economy in the use of timber prepared with sulphate of copper required our attention; and we have observed in the Reports made on the subject of the sleepers for the St. Quentin Railway, some elements which enable us to assign the extreme limit to the outlay required for this process, since the results obtained relate to the first application which had been made, and experience had yet to be gained.

The preparation of sleepers, cubing about 3½ ft. each, cost the contractor, on the average, about 11¼d., apportioned in the following manner:—

General Expenses	0⅝d.
Erection of Benches	0½
Carriage of Timber to the Benches	3⅛
Sulphate of Copper	5
Labour	2
Total	11¼

It is worth remarking, that the sulphate of copper having cost, together with the expenses of carriage, about 3¼d. per lb., the quantity used per mètre cube was about 15⅓ lbs., which shows a considerable loss, since the average weight of the sulphate absorbed per mètre cube (about 35 ft. English) did not exceeed from 11 lbs. to 13 lbs. By proceeding with greater care, and arranging the apparatus more conveniently, a smaller figure for the outlay might probably be arrived at. But such as it is, it may nevertheless be observed, that there is nothing extravagant in the expense of the process; and that the outlay will be well repaid by the advantage of being enabled to employ in permanent constructions white timber of much less value than oak, the use of which was only admitted on public works.

During the course of his operations, M. le Docteur Boucherie has been enabled to establish certain facts, which we believe may be usefully inserted here:—

1. All kinds of wood do not absorb equally.

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2. The absorption of the liquid is more rapid in the sappy parts than in the part nearer to the heart of the wood.

3. The quantity of liquid introduced into the timber is equal at least to one-half of its cube.

When a liquid, which contains about 2½ lbs. of sulphate of copper in every 22 gallons, has been forced through a log, it appears, after allowing for the sulphate carried off by the sap, that each cubic mètre of wood has retained from 11 lbs. to 13 lbs.

4. For a log about 8 ft. 6 in. long, the process of impregnation lasts two days when the timber is newly felled, and the supply-head at about 3¼ ft. elevation. If the wood has been felled three months, three days are required; if four months, four days are necessary to effect the impregnation.

5. The greater elevation of the cistern from which the liquid is supplied renders the process more rapid, and also more complete. This fact has been observed several times. It has been ascertained, for instance, that, during equal periods, a block of beech absorbed—

Under 3 ft. 3 in. pressure	...	...	15·00 oz. in ten minutes.	
„ 11 ft. 9 in.	...	...	...	50·30 oz. do. do.
„ 21 ft.	...	...	...	86·96 oz. do. do.

And that another block, felled some time previously, absorbed—

Under 3 ft. 3 in. pressure	...	...	1·78 oz. in ten minutes.	
„ 11 ft. 9 in.	...	...	...	19·40 oz. do. do.
„ 21 feet	...	...	...	33·50 oz. do. do.

This influence of pressure is only perceived in such penetrable woods as beech, hornbeam, birch, Scotch fir, &c. The attempts made to force the liquid, by means of pressure, into wood which, under ordinary conditions, is impenetrable, remain altogether without result. Thus it has been shown, by the experiments made at Toulon by M. le Docteur Boucherie and M. Sochet, marine engineer, that a pressure of upwards of 65 ft. produced no effect on a disc of heart of oak only 8 in. thick.

7. The increase in weight observed in the wood after its impregnation varies according to its nature, and depends on the

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quantity of air it contained, and which has been replaced by the liquid. We give some results, viz. :—

Beech	...	increased	209 lbs.	per mètre cube,	or 35 ft.	cube English.
Oak (sappy part only)		„	55 lbs.	„	„	„
Hornbeam	...	„	46 lbs.	„	„	„
Birch	...	„	2 lbs. 10 oz.	„	„	„
Poplar	...	„	70 lbs.	„	„	„
	...	„	50 lbs.	„	„	„
Alder	...	„	156 lbs.	„	„	„
Ash	...	„	50 lbs.	„	„	„
Scotch Fir	...	„	127 lbs.	„	„	„
White Fir	...	„	53 lbs.	„	„	„

8. The process may be carried on all the year round, excepting at temperatures so low as to freeze either the liquid to be injected or the sap which oozes out.

9. Those kinds of wood which possess most moisture, and, of the same kind, those which have grown in the dampest soils, are most easily penetrated. It follows that the least-esteemed kinds of timber, and consequently the cheapest, are precisely those which afford the best results when impregnated with the sulphate of copper.

We desired to make some experiments on the comparative resistance of timber impregnated, and in its natural state; but M. le Docteur Boucherie's indisposition prevented us from so doing. He has already made some at Compiègne, which seem to have been satisfactory. The details of them have not yet been ascertained; and the communication of them will be interesting. We shall make them the subject of a supplementary Report. We conclude, from the foregoing remarks :—

That extremely simple processes, easy and economical in their application, have been discovered and put in practice by M. le Docteur Boucherie, for the purpose of forcing into the substance of white woods of all sizes, liquids prepared to ensure its preservation.

That this injection, even in those kinds of wood most easily penetrated, is the more rapid in proportion as the tree contains more sap, and is the more recently felled.

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That certain kinds of timber are altogether impenetrable by the solutions.

That of all the liquids tried by M. le Docteur Boucherie, that consisting of sulphate of copper dissolved in the proportion of at least $2\frac{1}{4}$ lbs. to 22 gallons of water, is the only one which has maintained in a state of complete preservation, during a period of seven years, the blocks of beech and hornbeam which were subjected to experiment, and impregnated with this salt in the proportion of from 11 to 13 lbs. per mètre cube.

That white timber thus impregnated with sulphate of copper, and placed in the ground as railway-sleepers, or exposed to the action of atmospheric agency, lasts longer than oak unprepared, placed in the same situations.

That therefore it appears advisable to use in future for the purposes of construction, white timber, suitably prepared with sulphate of copper, when it is required to be employed under the circumstances already described.

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REPORT

ADDRESSED TO

THE MINISTER OF MARINE

ON

THE PROCESSES OF DR. BOUCHERIE

FOR

THE PRESERVATION OF TIMBER,

BY A COMMISSION, COMPOSED OF

MM. LEROUX, SOCHET, & DUPONY.

1852.

THE PERMANENT WAY COMPANY,

26, GREAT GEORGE STREET, WESTMINSTER.

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PRESERVATION OF TIMBER,

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Subject of the Report.—By a despatch of the 24th February, 1852, the Minister charged a commission, composed of

M. Leroux, Inspecteur-Général du Génie,
„ Sochet, Ingénieur de la Marine,
„ Dupony, Capitaine de Frégate,

to examine the results obtained by Dr. Boucherie in the working of his processes for the preservation of timber; and to point out what applications of those processes might be made with advantage in the naval service.

Date of the Invention.—We subjoin the result of his researches and observations on this interesting subject. The invention of Dr. Boucherie dates back about a dozen years; it became generally known through two Reports, eminently favourable,—that of M. Dumas, read at the Institute in 1840, in the name of a commission composed of the most eminent scientific men; and that of M. Arago, at the Chamber of Deputies in 1841. Nevertheless, it is only during the last eight years or so, and in consequence of the employment of the salts of copper,

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that applications of the invention, on a large scale, have been made in trade.

Fundamental Principle of the two Processes for the Preparation of Timber.—The fundamental principle of the system consists in forcing into the timber liquids of a preservative nature, by causing them to infiltrate into the vegetable fibre, as they would into an assemblage of hollow and parallel tubes.

In the first instance, M. Boucherie employed for this purpose the vital energy of the trees. He availed himself of the circulation of the sap to draw up, distribute, and disperse the liquid into every part of the wood, and even into the finest tissues of the leaves. But afterwards, considering that the sap retains the faculty of circulation for several days, even when the tree has been felled and stripped of its foliage, M. Boucherie substituted for the first process another system much more simple and economical, which consists in forcing the liquid into the trunk of the tree at one of its ends by simple pressure, by means of some sort of a cap or cistern which was fitted to it. The sap is then quickly displaced; it oozes out, and the timber is at once deprived of the most active agent of decomposition.

Mode of Operation.—M. Boucherie only employs this second process at present; but he has made great changes in the mode of operation. The same has happened to many others, who, in their experiments, have only been guided by the particular circumstances under which they have had to operate.

Thus, in the applications connected with railway-works, whenever a log is of sufficient length to be cut up into sleepers, M. Boucherie operates horizontally, by cutting a transverse saw-cut through the middle of the log, which he closes by means of a simple turn of a cord. He then introduces the preserving liquid into the cavity thus formed. In making the saw-cut, he takes particular care to leave untouched the tenth part of the section. This precaution is necessary to ensure to the system a proper stability.

For shorter pieces, M. Boucherie proceeds vertically either

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in a downward direction, by enveloping their large end in a pipe or hose of india-rubber cloth; or in an upward direction, by luting together with clay a large number of pieces in a great wooden case, in which they were immersed for two-thirds of their length. This second method is preferred, because it allows the air to escape more easily, and the section of the trunk through which the liquid is introduced always remains much cleaner; and it has been possible by this process to penetrate completely blocks of poplar, which could not be penetrated horizontally. Lastly, for the longest trunks, it is necessary to operate in an horizontal position.

M. Boucherie employs in this case a small tub luted with clay to the trunk, or a cap of thin lead, confined by an iron ring with a screw.

The Administration of the telegraph lines having to operate upon some thousands of trees of small diameter, and from 20 to 30 feet only in length, places the trunk almost vertically, keeping the large end upwards, and connecting it with a metallic tube in the form of a cone, to which it was luted with clay.

At Toulon, M. Sochet prepared some trees of great size, by placing them with a slight inclination, and by applying to the lower part, against the large end, a sheet of lead, which he fixed at a small distance from the bark, with common nails about $\frac{3}{4}$ in. long, extremely close to each other, and driven into the substance of the fibre of the wood. A band of sheep's skin $\frac{5}{8}$ in. wide was introduced between the wood and the lead, round the whole surface of the nailing; and lastly, a leaden pipe soldered to the leaden cap, served to introduce the liquid. This contrivance resisted successfully, when tried under a pressure of 20 feet.

In addition to these, many processes may be successfully applied. The preference must depend solely on particular circumstances connected with the locality, the price of labour, facility of transport, the number of pieces to be prepared, their size, &c., &c.; but the greatest importance should, under all circumstances, be attached to the condition that the liquids be

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perfectly limpid, and in no degree deteriorated by the clay which is employed in the joints.

Time required in the Preparation.—The time required for each operation is extremely variable. It depends on the season; —the period, more or less considerable, since the tree was felled;—the nature of the wood, &c. Two days, and even a few hours, are sufficient for short pieces. A fir 50 feet long requires a month; for beech or hornbeam of the same length, fifteen days frequently suffice.

Advantages of a considerable Pressure.—The impregnation may be hastened by employing a more energetic pressure. The use of the forcing-pump should, however, be avoided. M. Boucherie has seen an Italian poplar burst under a pressure of a few atmospheres. Too heavy a pressure may also be attended with the inconvenience of obstructing the vessels which contain the sap. M. Sochet has found that within certain limits the impregnation, measured by the flow of the liquids, was, in proportion to the pressure, in conformity with a very remarkable law of capillary tubes, which he had previously adverted to.

Consequently, for trees of great length, it will be advisable to employ a pressure of from 16 to 32 feet. The large end should be operated on, experience having proved that the impregnation is better effected in this manner. When, however, the trunks are very long, it will be advisable to operate in succession on both ends.

Of the Quantity of Matter to be introduced into the Timber. —The quantity of liquid to be introduced into the timber depends on the strength of the solution, and on the nature and destination of the piece to be prepared; it is impossible to define a rule on this subject.

A mètre cube of beech, manufactured into railway-sleepers, absorbs generally from 9 lbs. to 13 lbs. of sulphate of copper.

In some particular experiments M. Boucherie has observed

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the following augmentation in weight per mètre cube of timber:—

Beech	95	Impregnation complete.
Alder	71	
Fir	57·5	Impregnation incomplete.
Poplar	31	
Oak	25·5	
White Fir	24	
Ash	23	

Inequality of Penetration.—It may be seen by this table that the different kinds of wood do not absorb equally. This phenomenon does not depend on the density of the wood; for box absorbs tolerably well, whilst poplar frequently resists impregnation. This fact appears to depend principally upon the texture or organization of the vegetable fibre, and the particular disposition of the resins or resinous substances which obstruct the vessels, &c. &c.

There are some kinds of wood which can be completely penetrated in every part; such as the alder, hornbeam, beech, plane, willow, and poplar. In others, a central portion is left, more or less considerable, which resists impregnation. Sometimes the sappy part alone is affected: the oak is an example of this. But, in general, the parts penetrated are not altogether composed of the sappy portions, they are much more considerable; and when a coloured liquid is employed, they are seen to define themselves with great clearness, by forming through the annual rings of the timber sharp defined lines, quite irregular in their arrangement.

Of the Circumstances most favourable to Impregnation.—Timber absorbs, in general, with greater ease, in proportion as it has been the more recently felled. It is therefore most advisable that the process should be applied during the first fortnight, or even, if possible, in the first few days after felling.*

* Experience has, however, shown, that we can safely work in winter within three months of felling; in summer, within two months.—(Note of M. Boucherie.)

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A knot, or interruption of any kind, is sufficient to intercept the circulation of the liquid. Dead wood likewise resists the process of penetration. It follows from this, that great care should be employed in the choice of the timber on which to operate. All defective trees, and those whose appearance or foliage indicates the smallest decay, should be rejected.* M. Autier, who has executed many operations on a large scale, assures us, that in proceeding in the above manner with care and discernment, success may be considered as certain.

The youngest trees are prepared the most easily and completely. In a Scotch fir of forty years old, which the Commission caused to be operated on, there were only the four most central rings which were not penetrated.

Lateral Absorption.—The duration of the process is at times not altogether without advantage, because, in addition to the longitudinal penetration by means of the capillary tubes, there is going on a sort of lateral impregnation or absorption. M. Sochet, in operating on a white fir which had been prepared two or three months, and the heart of which had completely resisted all efforts, saw the liquid penetrate, for a length of a foot or two, into the very middle of the most central rings.

May we not hope one day to be enabled, by this method or by some other process, to arrive at the complete penetration of various kinds of timber, whose heart has hitherto resisted obstinately every effort? There is certainly some probability of this important problem being one day solved. We might cite several facts in support of this opinion; but these considerations are too abstract to be inserted in this Report. Our duty confines us simply to the record of facts observed.

It should, however, be mentioned, by way of note, that M. Boucherie has provided in his patents for the simultaneous employment of the vacuum produced at the other end of the log, by some physical or mechanical agent, and that a company is being now organized in Paris, for the complete pene-

* This can only relate to timber for ship-building purposes, the value of which is always considerable.—(Note of M. Boucherie.)

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tration of all kinds of wood, even when felled for some years, by means of the combined and successive action of the vacuum, and a strong pressure, communicated by means of iron cylinders.

Choice of the preserving Liquid.—The choice of the preserving liquid has deeply engaged the attention of Dr. Boucherie. At first, he preferred the pyrolignite of iron; the idea of preserving wood, by turning to account the chips and waste produced in its preparation, by the manufacture of the pyrolignious acid, had something attractive in it; but experience has not fulfilled his anticipations. The oxide of iron, in the course of time, affects the woody fibre just as ink affects linen; and as nailing injures timber, and particularly the sheeting of vessels. Besides, the experiments at Toulon and L'Orient have proved that the pyrolignite of iron does not keep off the worm or the teredo. After protracted researches, M. Boucherie has definitely adopted the sulphate of copper, which appears to be, in fact, a substance of an eminently preservative nature. This circumstance is essential: for it constitutes the whole practical merit of M. Boucherie's processes. For this reason, we have attached the greatest importance to its investigation; and have thought it our duty to enter into somewhat minute detail on this subject.

Experiments at the Pheasantry of Compiègne.—Other experiments on preservation have taken place at the pheasantry of Compiègne, before a numerous commission; amongst whom were MM. Avril, Didion, and Mary, inspecteurs-divisionnaires des ponts-et-chaussées. Various blocks or pieces of beech, some in their natural state, and others impregnated entirely, or for one half of their length only, had been half-buried in the ground. At the end of seven years, all the timber left in its natural state was affected, or even entirely decayed; whilst the prepared timber remained quite uninjured. These results were certified to us personally by M. Mary.

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Posts for the Telegraph Lines.—But the most remarkable and conclusive facts, because on a larger scale, are those which relate to the posts of the electric telegraph lines, and to railway sleepers.

The facts referring to the posts were observed on the Northern Railway. We shall give the words of M. Alexander, administrateur-adjoint des télégraphes, on this subject.

In 1849, he wrote as follows:—

"The experiment we have tried on the Northern line possesses great "importance to the State, because it permits us to erect and maintain the electric "telegraph lines with great economy. The Rouen line was constructed with "oaken posts of too slight diameter. Each ordinary post however cost, *fixed*, "16 francs; the tightening posts, 40 francs; the crossing posts, 70 francs. The "line has been constructed since 1845, and already we are compelled daily to "replace the decayed posts with posts of preserved fir.

"The posts of preserved fir which were employed in the construction of the "Northern line, cost, as near as possible, fixed complete:—

"Ordinary and tightening posts, 5 francs 50 centimes (in place of 16 and "40 francs); crossing posts, 9 francs (instead of 70 francs).

"I do not anticipate that any further outlay will be required in the renewal "of these posts."

These remarkable results have also been communicated to us personally by M. Foy, administrateur-en-chef des télégraphes; and by M. Alexander, who has declared, in addition, that the posts on the Rouen line are at present totally decayed, whilst not one of the posts on the Northern line has suffered any damage. He added, that the posts of fir, not impregnated, were cut off level with the ground in the space of two years; and that at present the authorities regarded the mass of facts as so decisive, so conclusive, that the posts prepared with the sulphate of copper were taken by them into general use, to the exclusion of all others; and that they were at this moment engaged in preparing some thousands of others in the Landes of Bordeaux, and in Switzerland.

The Commission did not content itself with verbal inquiries. Two of its members proceeded to the Northern line, accompanied by M. Alexander, who displayed the most laudable anxiety to assist them: and there they examined a great number of

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posts with scrupulous attention. They bored holes in some of them, and found them all in a perfect state of preservation. One post, pointed out and marked by the Commission, was taken up, carried to the Ministère de la Marine, and cut across in different places. This post was found, like all the rest, in excellent preservation. Not a fraction of its thickness was damaged, after remaining in its position during a period exceeding six years. The marks left by the hatchet at that period, and the splinters which were partly detached, were also quite as sharp and as uninjured as when the post was placed in the ground; in a word, the success of the operation was complete.

Railway-Sleepers.—Nearly equal success has been remarked in the case of the sleepers of the Northern Railway. 500 of these sleepers, of beech impregnated with sulphate of copper, were placed in the ground, nearly six years ago, in the neighbourhood of La Chapelle, interspersed with about thirty pieces not prepared.

One of the inspectors of the line, M. Alquier, ingénieur des ponts-et-chaussées, informed us that the prepared beech was entirely preserved, whilst that left in its natural state was completely decomposed. The prepared beech, M. Alquier told us, has already exceeded in durability oak itself; and the officers of the line value it equally high, although, among the trees prepared, there are frequently some which are not so in their whole substance, and which in this case, decay in a very short time.

30,000 sleepers of prepared beech were similarly employed in 1847, on the line from Creil to Compiègne: no trace of decay has yet been manifested.

Splitting of Beech Timber.—Thus, then, as regards their preservation, prepared beech and fir have everywhere given results equally favourable; but the same cannot always be said as regards their use. M. Maoy, who spoke to us in the highest terms of all the particular facts which he observed, cited a bridge

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constructed with beech prepared with sulphate of copper, in which this wood became very much warped and split.* Other similar instances may have occurred under M. Autier. Nevertheless, this last-named engineer only attributes it to the careless manner in which the wood may have been worked or prepared.

Employment of the Deliquescent Salts.—Moreover, M. Boucherie pointed out some time since the deliquescent salts as possessing the property of preventing the splitting and warping of wood, even when exposed to the sun and to the vicissitudes of the weather. In this manner he prepared several trees, at Thorene, with chloride of calcium. Some of these remained still at Toulon at the time of the arrival of the Commission of Inquiry. M. Sochet caused them to be tested in presence of the Commission; they were found to be in a state of perfect preservation, although they had during eight years remained exposed alternately to excessive moisture and a burning sun: some small cracks were scarcely observable; any one would have said that they had just been prepared. The flexibility of the timber seemed to be in no degree altered. The end of a block was covered in, and subjected to the action of a small column of water, which it soon permitted to soak in, in much the same manner as newly-felled timber would do.

M. Sochet has quoted two more very remarkable examples of the effect produced by the chloride of calcium. Two thin planks of plane-tree wood, felled the day before, and prepared with chloride of calcium, were subjected for several days to the action of a very sharp current of air: they were not warped. Some white-lead paint applied on one of their surfaces remained closely adhering, without scaling off in the smallest degree.

On the transport *La Provençale* the outer covering of the quarter-galleries was entirely executed with thin boards of various kinds, prepared with chloride of calcium: the most

* This result was inevitable, because, contrary to M. Boucherie's recommendation, the timber was used the very day after its preparation, and, consequently, in a state of excessive moisture.—(M. Boucherie's note.)

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burning sun could hardly open the joints in any sensible degree.

M. Autier ascribes the same property to the mixture of sulphate of copper with the deliquescent salts: he says he has tried it on beech.

Inflammability of Timber treated with the Chloride.—Timber treated as above with the chlorides and deliquescent salts, possesses another very remarkable property; viz., difficulty of combustion.

In an experiment made by M. Boucherie at Toulon, M. Sochet saw a deal box, made of boards roughly put together, only slightly carbonized on the inside after the burning of a considerable quantity of shavings, with which it had been completely filled.

Substitution of White for Hard Timber.—The processes of M. Boucherie not only offer the advantage of increasing the durability of the better kinds of forest timber; they are especially valuable in this respect, that they permit the substitution of timber of very inferior quality, which was scarcely fit for use, and was consequently of little value, for the better and more costly descriptions.

One condition of this substitution would be that the process itself should be of small cost: and this precisely occurs; for the impregnation of a mètre cube of beech does not cost more than 12 francs.

In the case of round timber, which is intended to be used in that form, the cost will generally be more than repaid by the conversion of the sappy parts. These last become frequently of the same quality as the sound wood. We shall hereafter cite several facts in support of this assertion.

For square timber the cost will be much greater, on account of the loss of the salt of copper in the cuttings and waste pieces; but even if the cost per mètre cube be increased on this score from 12 to 20 francs, this expense will become of very secondary importance.

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Of Beech considered as a Building Material.—Of all descriptions of timber which we might hope to employ with advantage in our naval service, the beech must be mentioned in the foremost rank. This tree is at once one of the finest and the most abundant of those which are to be found in our forests. From the regularity of its proportions, and the greatness of its dimensions, it is well calculated to be employed in cross-planking, sheeting, beams, stanchions, floor-timbers, &c. &c.; but hitherto the navy has been able to make but very little use of it, because its wood could not resist the alternations of moisture and dryness. It has been sometimes used for planking at the water-line, when vessels are required to be quickly launched; but only in that case, and with the foreknowledge that in the case of repairs which require the vessel to be laid dry, the planking will immediately crack and split, and quickly become quite unfit for service.

We have already seen that the sulphate of copper sufficed to preserve the wood, and this salt does not diminish its strength. A great number of experiments, made by the engineers of the Ponts-et-Chaussées attached to the Northern Railway, have established this fact incontestably. According to other experiments, beech newly felled is nowise inferior to oak in strength, flexibility, and toughness.

It follows, from all these facts, that the possibility of one day employing beech for parts of ship-building depends solely on the choice of some very hygrometric substance, which, being mixed with the sulphate of copper, shall preserve, in all its force, the freshness and suppleness of the wood, and thus prevent it from cracking. M. Boucherie has discovered this substance in the chloride of copper, which is very deliquescent, and which does not in any way affect the sulphate with which it is mixed. But in what proportions should this mixture be made? Will it not lose its properties in time? Will not the deliquescent salt disappear by degrees on contact with the water, in the same manner that the corrosive sublimate disappeared, in five or six months, in the experiments quoted by M. Sochet?

These are questions which practice can alone resolve. We

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may be allowed to hope for a satisfactory solution of them; and it is advisable that the naval service should make earnest endeavours to attain it; but it is indispensably necessary to proceed with great caution and prudence.

Corrosion of the Iron Nails, &c.—With the use of the deliquescent salts, the corrosive action which may be exercised on the iron nails and bolts is to be much dreaded. M. Autier considers this action as principally dangerous in contact with the air. M. Legrix, at L'Orient, has likewise found that iron, even when galvanized, was severely attacked by the combined action of the sulphate and the pyrolignite of iron with the chloride of sodium. Some very careful experiments should be made on this subject; for it might cause actual danger to the vessels. However, this inconvenience would not apply to the sheeting under water, which is nailed and bolted with copper; and, in case of need, this latter metal might be substituted for iron for nailing the in-board sheeting, beams, &c. The result of this innovation would resolve itself into an addition to the value of the wood; and it would be necessary to calculate, in each particular case, what the real saving would be.

Of the resinous Timbers suitable for Masts.—After the beech, we may mention, as capable of offering the greatest advantages to the naval service, the different kinds of firs, the larch and the white fir. It is with a view to the employment of these trees in the making of masts that the experiments should be directed, on account of the scarcity and high price of the timber which they will probably replace. The trees to be selected for the preparation should be the most vigorous, the youngest, and those in which the proportion of the sap-wood is the most considerable.

To take an example;—the Corsican fir, from observations made by a former inspecteur-général du génie maritime, M. Bonnard, on twenty-four trees, of an average diameter, at the base, of 2 ft. 6 in., gives the mean thickness of sound wood, 1 ft. 8 in., and that of the sap-wood about 10 in. In section,

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therefore, the sap-wood presented very nearly the same surface as the sound wood. In this particular instance it is evident that theoretically M. Boucherie's process would double the cube of the timber, and increase the "palming" one-half. In practice, however, the advantage would be much less considerable, because, in order to round a mast, it is indispensable to cut away a greater or less quantity of the sap-wood; but even if the "palming" be only increased one-quarter, and the cube one-half, the result would nevertheless be an incontestable advantage, and a considerable saving.

The white fir should likewise be prepared for masting. M. Sochet mentions on this subject numerous experiments made by him in 1840, in the course of a visit to the forests of the north-west of the department du Var; experiments which he detailed in a memoir addressed at the time to the Minister of Marine; and from which it is concluded that the white fir, as well as the sap-wood of the Scotch fir, when newly felled, and selected with some care, are capable of rivalling, in point of strength and toughness, the timber of the topmasts used in our ports. The proportion of deliquescent salts should be considerable; but it is still experience alone which must determine the quantity.

Advantages and Saving already effected by M. Boucherie's Processes.—M. Boucherie's processes appear likely to render great service in industrial undertakings. Their value is no longer problematical, for as regards the posts of telegraph lines, and railway works, their success is complete.

Thus we may already consider that this discovery has enabled the State to effect a saving of one million francs on the telegraph lines. This saving results from the substitution of 100,000 posts of impregnated fir, costing six francs on the average, for 100,000 posts of oak, which would have cost sixteen francs on the average, and which, nevertheless, would have lasted a less time. The annual saving might be estimated at about 200,000 francs. It will increase in future by reason of the increased number and importance of the telegraph lines.

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With regard to the beech railway-sleepers, the experiments have not yet been sufficiently extended to calculate with certainty the saving which will be effected; but the fact of the saving is not the less indisputable.* It is beyond doubt that within a very brief period, the substitution of beech for oak will allow considerable quantities of oak to be retained for the demands of manufacturers and navigation, which would otherwise have been entirely devoted to the formation of railway-sleepers.

The Administration of the Navy must make further Experiments.—The naval service can no longer keep behind the progress in other branches of manufacture; and when on all sides applications of M. Boucherie's processes are being made on a very large scale, it cannot refuse to pursue with activity the experiments already commenced at Toulon and L'Orient; and which were only abandoned in consequence of the mistaken use of pyrolignite of iron as a means of preservation, and of the fire at Mourillon, which destroyed the timber about to be experimented on by M. Sochet.

It remains for us to point out the bases on which the experiments should be founded.

As we have already observed, it is absolutely necessary to conduct the operations under satisfactory conditions, and consequently on trees perfectly sound and of good quality. Of the resinous trees, the preference should be given to those which have proportionally the greatest amount of sap-wood.

Attention should be solely directed to the impregnation of the beech and Scotch and white firs. The Commission considers it indispensable that M. Boucherie should himself be employed to prepare all the timber required for the experiments. Under his eyes we have the best guarantee the service can possess, of intelligent and conscientious treatment, particularly as regards

* Some beech sleepers were removed from the Northern line to be sent to the Great Exhibition in London, which, after five years' service, were found to be in a state of perfect preservation. MM. Maniel and Alquier have certified the fact by a procès-verbal.

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the selection of the preserving liquids, and the most suitable proportions to be observed in mixing them; besides, it is the surest method of preventing subsequent complaints or disputes, which might not be altogether groundless.

Experiments should be made with these woods simultaneously in the two ports of Brest and Toulon.

The building-timber so prepared should be employed in the construction of hulks, in order that a more strict and uninterrupted surveillance may be exercised as to the manner in which they wear, their action as regards the nails and bolts, and especially because no danger can result from their use.

Beams of beech should be employed in construction of gridirons on shore in places where oak is most speedily attacked. The balk fir should likewise be tried in the most unfavourable situations.

As regards masts, as they only can be tried at sea, a mast should be prepared for one of the transports, which are accustomed to make the shortest and least hazardous voyages.

Lastly, the blocks specially prepared for experiments should serve to form bars, for the purpose of being carefully tested under the three heads of strength, toughness, and durability, under the changes of the weather.

The quantity of timber required may be fixed nearly as follows for each of the two ports of Brest and Toulon :—

I. Beech.

1. Timber prepared with the mixture of the preserving and deliquescent salts.

Planking for one-half the bottom and the out covering of a hulk.

Planking for one-fourth of the inner covering of ditto.

Six stanchions for ditto.

Six beams in one piece for ditto.

Six beams in two pieces for ditto.

Planking for the construction of three ships' launches.

2. Timber prepared with sulphate of copper only.

Planking for the interior covering of a hulk.

Six mètres cube of logs or planks.

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II. Scotch Fir.

Timber prepared with the mixture of preserving and deliquescent salts.

The timber required for the construction of two masts complete, one as a reserve, for the rigging of a transport.

Two mètres cube of balks, prepared in various ways, for experiments.

III. White Fir.

1. Timber prepared with the mixture of the preserving and deliquescent salts.

The timber required for the construction of two masts complete, one as a reserve, for the rigging of a transport.

2. Timber prepared with sulphate of copper only.

Fifty stay-timbers, from 30 to 50 feet long.

SUMMARY OF THE REPORT.

To sum up what has been above stated:—1. The Commission has shown that the sulphate of copper has been employed with the greatest success, by means of M. Boucherie's processes, in preparing telegraph-posts of resinous timber, and railway-sleepers of beech.

2. That the telegraph-posts have already lasted more than six years, without the slightest alteration, in situations where fir posts, not prepared, were cut off level with the ground in two years, and oak itself in less than six years.

3. That prepared beech scantling, used as railway-sleepers, has suffered no change by remaining six years in the ballast; and that under these circumstances its durability exceeds that of oak; and that the strength of timber prepared with the sulphate of copper, or with the deliquescent salts, is not perceptibly inferior to that of timber in its natural state.

4. But that beech prepared with sulphate of copper only is liable to split on exposure to the air; and that which con-

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tains the deliquescent salts attacks more or less severely the iron nails and bolts.

5. That, nevertheless, these two defects do not appear to be beyond remedy.

6. In consequence of and considering the immense advantages, and especially the saving which may be effected by the application of M. Boucherie's processes to the requirements of the naval service, the Commission is unanimously of opinion:

a. That there should be no hesitation in resuming immediately, and under the conditions described in this Report, the experiments which had been commenced at Toulon and L'Orient.

b. That fresh experiments should be made solely on beech prepared for the purposes of construction, on pine and fir for masting, and on white fir intended to be used as stay-timbers.

c. That it will be advisable to operate only on very sound trees, of good quality, and which offer the requisite guarantees of success.

d. Lastly,—That M. Boucherie should be employed to prepare and furnish all timber to be subjected to the experiments, which will take place simultaneously in the two ports of Brest and Toulon.

The Members of the Commission,

(L.S.) LEROUX, DUPONY, SOCHET.

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EXTRACT

FROM

THE OFFICIAL JURY REPORT

OF THE

Universal Exposition of Paris

IN 1855.

SECOND CLASS, THIRD SECTION.—FOREST INDUSTRIES.

1855.

THE PERMANENT WAY COMPANY,

26, GREAT GEORGE STREET, WESTMINSTER.

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EXTRACT

FROM

THE OFFICIAL JURY REPORT

OF THE

Universal Exposition at Paris

IN 1855.

Second Class, Third Section.—Forest Industries.

Extract from the Official Report.

"AMONGST the many materials which man borrows from Nature to construct his dwellings, his means of communication, his ports, his monuments of all descriptions, is there one so precious as wood? But is there a substance whose preservation merits more to be considered? This tree, whose good qualities provide for so many useful works, and which humidity and insects destroy so quickly, this timber itself, is the fruit of a long work of time; it has demanded a century or more to give it to man,—it will require quite as many years to form one to replace it. However, the demand increases and the sources become exhausted,—what benefit would there not be then in converting into durable wood, and susceptible of the same services as the oak and similar timbers, those white woods, whose growth is in general incomparably more rapid? To solve such a problem is to create new forest riches; for from henceforward our white woods can serve for the same purposes as our hard timber, and these valuable trees, properly managed, will remain on our soil, from which constantly increasing exportation threatened to make them disappear. In the opinion of the jury of the 2nd Class, the examination of the preparative processes proper to

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insure the preservation of timber, was then one of the most important questions which they had to consider.

"An exhibitor, long known by his works and his success in this subject, Dr. Boucherie (No. 241), France, has incontestably solved this great problem of general interest; it is with the guarantee of an experience of fifteen years, with numerous operations representing the value of nearly 6,000,000 francs (£240,000), and crowned with an entire success, that the jury in the course of its work awarded Dr. Boucherie the medal of honour, the highest reward which they could then give; but to show what particular value they attribute to his discovery, the 2nd Class reserved to itself the power to recommend the Doctor especially to his Majesty the Emperor for a promotion in the order of the Legion of Honour, of which he is already a member (although) exhibitor. As soon as the decree of the 9th of November had created, in the *great* medal of honour, the highest reward which an exhibitor could merit, on the proposition of the 2nd Class, expressed by Sir William Hooker, the president, and Professor Milner Edwards, the vice-president, the Council of Presidents decreed one of these to Dr. Boucherie.*

"The 2nd Class have had the gratification to receive from another class, the 14th, a confirmation of their judgment relative to this important question; our honourable presidents were enabled to present themselves before the Council, with a letter, in which the president of the 14th informed the president of the 11th, that they *would have* awarded to Dr. Boucherie the same reward, if they had not known the proposition of which he was already the object.

"Professor Brenguiast, whom the jury had particularly charged with the examination of Dr. Boucherie's process, and of the woods exhibited by him, has conveyed in the following words the high expression of his judgment:—'Fifteen years ago Dr. Boucherie, directed by very just scientific ideas, endeavoured to make different solutions penetrate into wood by the

* Only four of these large gold medals of honour were conferred on the expositors.

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same means which cause sap to rise in the woody tissue. His processes, notwithstanding the modifications to which he has subjected them, to render them of an easier application, are all based on this principle, 'that the liquid which ought to give to the wood certain qualities, which should replace the sap existing there, penetrates into all the spaces it previously occupied, and expels it entirely.' Dr. Boucherie first used the force of suction, which the leaves exercise, to endeavour to make the preserving liquid, which ought to replace the sap, penetrating into the tree while it was still living. This process, very simple in appearance, was very difficult to apply to large pieces of timber, and ought also to be executed on the spot where the tree was cut down, and immediately after its fall. Very soon Dr. Boucherie saw that he could dispense with these various conditions; that a feeble pressure of two or three mètres of water could replace the force of ascension of the sap, and that it sufficed that the wood was still green, saturated by the sap, to enable the preserving liquid to penetrate into its tissues, drive out the sap which was in, and occupy its place, and deposit the matter which should insure the preservation of the wood.

"'In acting upon timber which has been cut down two or three months or more, and still filled with sap, in making the preserving liquid penetrate at right angles to the trunk, and making the sap run through the transverse section by means of this feeble pressure, the operation of perfect preservation can be performed in a time which varies from a few hours to two days at most, according to the size of the piece of wood and the nature of the tree.

"'All the watery solutions can in this manner penetrate the tissue of the wood, and there deposit the matter which they hold in solution; numerous trials have now proved that the sulphate of copper is the salt which best insures the preservation of the wood exposed to the most unfavourable atmospheric circumstances.

"'All woods are penetrated by this solution in those parts in which the sap naturally rises in their trunks; but in many trees the oldest part, viz. the heart, where certain portions of

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each annual layer (or ring) are soon entirely filled up, and are entirely without the flow of sap, these portions are not penetrated by the preserving fluid; but they are such as are naturally almost unchangeable, resisting every cause of decay. It results from this fact, that in the wood with a hard heart, like the oak, it is the sap-wood which becomes penetrated and becomes unchangeable as the heart itself; that in the wood where the heart does not harden, and which is easily changeable all through, like the beech, the hornbeam, the birch, the alder, the fir, all the parts being soft, become unchangeable, by the complete penetration of the preserving liquid, which insures to wood of very bad quality a durability greater than that of the heart of the oak of the first quality.'

"The facts which we have just stated have already been proved some years back, and reports addressed both to the Minister of the Public Works by a committee of engineers, appointed by the Board of Ponts-et-Chaussées (of Works and Ways), and to the Minister of Marine, by a committee belonging to the marine corps, made known the results obtained by experiments made on a very large scale.

" Now we have to establish the fact, that these processes are applied by Dr. Boucherie in a practical manner, that they are rendered very simple, and very easy of application, are employed with great advantage on many railways, and also for the posts of the telegraphic lines. The most extended application has been made on the 'Chemin de Fer du Nord,' comparatively with many other processes for the preservation of wood.

" Since 1846, 80,000 sleepers, prepared by Dr. Boucherie, have been fixed on this railway. The excellent state of preservation of these sleepers has been the cause of 309,000 more being ordered since 1853; and the Directors of this railway add that some new contracts are preparing for 200,000 sleepers. Comparing those prepared by Dr. Boucherie with those subjected to other processes of penetration or external application, which have been employed on a large scale on the same line, the Directors of the Chemin de Fer du Nord expressed themselves as follows :—

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"'The process of Dr. Boucherie has produced results the most satisfactory, when the preparation is complete: his sleepers prepared by this process are thoroughly preserved; those in use since 1846, which have been well prepared, are now exactly as good as on the day they were laid down. In general, the whole preparation is good; and further we add, their preservation at the end of eight years is such, that it is not possible to foresee any limit to their durability. These sleepers are beech, hornbeam, birch, and pine. When they are prepared, they are as good as the sleepers made of the heart of the oak, and they are to be preferred to these last. The Directors of the telegraphic lines confirm the efficacy of this process of injection applied to the posts of pine which hold the wires of the electric telegraph. 190,000 posts were erected the 1st of January, 1855; 30,000 will be prepared in 1855. The preservation of these posts, which were injected with sulphate of copper in 1846, at which time the first of them were put down, is entire. It is known that posts of this sort not thus prepared decay very rapidly, especially at the ground-level. It results from these well-ascertained facts, and from others too numerous to mention here, that Dr. Boucherie's process has given the most certain results for the preservation, in very unfavourable circumstances, of woods of a naturally perishable kind; that the process gives to woods of cheap and abundant kinds the possibility of extensive application, and is also of great importance at a time when railways render the consumption of ordinary woods so large, that oak alone would last but a few years.' "

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TABLE

SHOWING THE

RESULTS OF EXPERIMENTS

MADE

AT DERBY BY MR. W. H. MILLS FOR MR. P. W. BARLOW,

UPON

VARIOUS DESCRIPTIONS OF TIMBER

PREPARED BY

DR. BOUCHERIE'S PATENT PROCESS

FOR

Preserving Wood from Decay.

1856.

THE PERMANENT WAY COMPANY,

26, GREAT GEORGE STREET WESTMINSTER.

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THE "Results of Experiments upon various descriptions of Timber prepared by Dr. Boucherie's Patent Process for Preserving Wood from Decay," were made at Derby, for Mr. P. W. Barlow by Mr. W. H. Mills, in May, 1856, and were conducted under a pressure of 30 feet.

THE PERMANENT WAY COMPANY have published a full description, with Illustrations, of Dr. Boucherie's Patent Process for Preserving Wood from Decay; also the French Official Reports upon the Process, made by order of the French Government; each of which may be had, post free, together with any information on the subject, upon application to the Secretary,

WILLIAM HOWDEN.

26, GREAT GEORGE STREET, WESTMINSTER,
August, 1856.

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SUMMARY OF EXPERIMENTS.

No. of Experiment.	Date.	Description of Wood.	When cut down.	Length.	Average Diameter.	Cubic Content.	Amount of pure Sap forced out before Solution perceptible.	Amount of Solution used to effect this.	Time in forcing pure Sap out.	Total Amount of Solution run out of Tank during operation.	Time of Operation.	Amount of Solution used per cube foot.
				Feet.	Inches.	Feet.	Quarts.	Quarts.	Hours.	Quarts.	Hours.	Quarts.
1	April 29, 1856	Beech	January, 1856	18	12¼	14¾	33	64	4	104	8½	7·04
2	May 1, 1856	Spruce Fir	April 23, 1856	18	11¼	13½	27	50	5	95	12	7·00
3	May 5, 1856	Poplar	April 1, 1856	18¼	11¼	13½	Copper perceptible from commencement			130	11	9·60
4	May 7, 1856	Elm	Dec. 1855	18	11¼	13½	—	—	—	156	23	11·52
5	May 9, 1856	Alder	Feb. 1856	18	11	12	43	58	1½	176	31	14·64
6	May 10, 1856	Memel	—	18¼	11by11	15¼	Copper perceptible from commencement			230	50	15·08
7	May 22, 1856	Birch	May 21, 1856	18	12¼	14¾	32	34	25 minutes	184	3½	12·00
8	May 23, 1856	Scotch Fir	—	18	12¼	14¾	35	47	6	130	58	8·80

DERBY, *May 26th*, 1856.

W. H. MILLS.

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DETAILS OF EXPERIMENT No. 1.

BEECH.

TIME.	Time running quarter-pint of Liquid.				Quantity of Liquid ran out of Tree.	Quantity of Solution ran out of Tank.	Amount ran out of Tree in half-hour.	Amount ran out of Tank in half-hour.	REMARKS.
	Root end.		Top end.						
	m.	s.	m.	s.	Quarts.	Quarts.	Quarts.	Quarts.	
1st half-hour	0	38	1	19	4½	17	4½	17	Pure Sap began to run out, and drop quickly, immediately pressure was turned on.
2nd „ „	1	6	1	24	10	28	5½	11	
Pressure taken off, and Tree left during night, when 4 quarts of Sap ran out, making the total amount before commencing again					14				
3rd „ „	2	0	„	„	16½	40	2½	12	
4th „ „	1	38	„	„	19½	44	3	4	
5th „ „	1	40	„	„	23	50	3½	6	
6th „ „	1	39	2	8	26½	54	3½	4	
7th „ „	1	38	1	58	29½	58	3	4	
8th „ „	1	43	2	0	33½	64	4	6	Copper just perceptible in liquid coming out of Tree.
9th „ „	1	50	2	4	36½	68	3	4	
10th „ „	1	51	2	11	40	72	3½	4	
11th „ „	1	55	2	15	43½	76	3½	4	
12th „ „	1	54	2	13	47	80	3½	4	
13th „ „	1	58	2	18	50	84	3	4	
1½ quart ran out in night					51½	total amount		—	
14th „ „	1	59	2	28	55	92	3½	8	
15th „ „	2	2	2	27	58	98	3	6	
16th „ „	1	58	2	10	61	100	3	2	
17th „ „	2	4	2	38	64	104	3	4	

This Tree was cut up into Sleepers; the Copper was strong at the sides, but not perceptible in the heart of the wood.

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DETAILS OF EXPERIMENT No. 2.

SPRUCE FIR.

TIME.	Time running quarter-pint of Liquid. Root end.	Time running quarter-pint of Liquid. Top end.	Quantity of Liquid ran out of Tree.	Quantity of Solution ran out of Tank.	Amount ran out of Tree in half-hour.	Amount ran out of Tank in half-hour.	REMARKS.
	m. s.	m. s.	Quarts.	Quarts.	Quarts.	Quarts.	Pure Sap began to drip at each end in 8 minutes after pressure was turned on.
1st half-hour	,, ,,	,, ,,	1	10	1	10	Dropping faster at top end than at root.
2nd ,, ,,	only dropping	1 29	4	16	3	6	
Ran 2 quarts in night			6	total amount			
3rd ,, ,,	3 45	1 50	8	24	2	8	
4th ,, ,,	3 50	1 42	11	30	3	6	
5th ,, ,,	4 3	1 48	14	33	3	3	
6th ,, ,,	3 58	1 47	16½	37	2½	4	
7th ,, ,,	3 49	1 45	19½	40	3	3	
8th ,, ,,	4 4	1 45	22	44	2½	4	
9th ,, ,,	4 14	1 49	24½	47	2½	3	
10th ,, ,,	4 21	1 58	27	50	2½	3	Sulphate of copper just perceptible.
11th ,, ,,	4 28	1 57	29½	53	2½	3	
12th ,, ,,	4 32	2 3	32	56	2½	3	
13th ,, ,,	4 37	2 2	34½	59	2½	3	
14th ,, ,,	4 36	4	37	62	2½	3	
Ran 3 quarts in night			40	total amount			
15th ,, ,,	6 4	2 16	41½	68	1½	6	
16th ,, ,,	4 50	2 14	44	71	2½	3	
17th ,, ,,	4 34	2 9	46½	74	2½	3	
18th ,, ,,	4 28	2 16	49	78	2½	4	
19th ,, ,,	4 35	2 15	51½	81	2½	3	
20th ,, ,,	4 33	2 16	54	84	2½	3	
21st ,, ,,	4 31	2 14	56½	87	2½	3	
22nd ,, ,,	4 29	2 17	59	90	2½	3	
23rd ,, ,,	4 32	2 15	61½	93	2½	3	
24th ,, ,,	4 33	2 15	64	95	2½	2	
Ran 2 quarts in night			66	total amount			

This Tree, on being cut up into Sleepers, showed that the Solution had not penetrated into the heart of the wood, but was very strong at the sides.

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DETAILS OF EXPERIMENT No. 4.

E L M.

TIME.	Time running quarter-pint of Liquid.		Quantity of Liquid ran out of Tree.	Quantity of Solution ran out of Tank.	Amount ran out of Tree in half-hour.	Amount ran out of Tank in half-hour.	REMARKS.
	Root end.	Top end.	Quarts.	Quarts.	Quarts.	Quarts.	
1st half-hour	Unable to take the time, the liquid dropping from several places.		1	14	1	14	Began to drop at top end in 3 minutes after pressure was turned on. Copper perceptible in 10 minutes. Began to drop at root end in 12 minutes. Copper imperceptible.
2nd „ „			2½	20	1½	6	Copper perceptible at root end.
3rd „ „			5	26	2½	6	
4th „ „			7½	28	2½	6	
5th „ „			9½	33	2	5	
6th „ „			11½	37	2	4	
7th „ „			13½	41	2	4	
8th „ „			15½	44	2	3	
9th „ „			17½	47	2	3	
10th „ „			20½	52	3	5	Liquid still dropping faster from top end than root.
Pressure left on all night; 104 quarts ran out of the Tank during the 18 hours, making a total of 156 quarts in 23 hours.							

Solution of Copper perceptible in heart of this Tree, but not so strong as at sides.

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DETAILS OF EXPERIMENT No. 5.

ALDER.

TIME.	Time running quarter-pint of Liquid. Root end.	Time running quarter-pint of Liquid. Top end.	Quantity of Liquid ran out of Tree.	Quantity of Solution ran out of Tank.	Amount ran out of Tree in half-hour.	Amount ran out of Tank in half-hour.	REMARKS.
	m. s.	m. s.	Quarts.	Quarts.	Quarts.	Quarts.	
1st half-hour	„ 27	„ 39	12	20	12	20	Began to run fast at both ends immediately pressure was turned. Pure Sap in both cases.
2nd „ „	„ 26	„ 37	27	40	15	20	
3rd „ „	„ 26	„ 37	43	58	16	18	Copper just perceptible at both ends. Left off for night (six days elapsed before continuation of this experiment).
4th „ „	2 31	2 39	46	66	3	8	Liquid coming out a strong brown colour.
5th „ „	2 38	2 37	49	71	3	5	
6th „ „	2 40	2 39	51½	76	2½	5	
7th „ „	2 41	2 38	54	79	2½	3	
8th „ „	2 49	2 59	56	82	2	3	
9th „ „	3 14	3 18	58	85	2	3	
10th „ „	3 29	3 32	59¾	88	1¾	3	Brown tint, much lighter.
11th „ „	3 34	3 31	61½	90	1¾	2	
12th „ „	3 53	3 51	63	93	1½	3	
13th „ „	3 52	3 54	64½	96	1½	3	
14th „ „	3 54	3 53	66	99	1½	3	
15th „ „	Only dropping		67	102	1	3	
16th „ „	slightly		68	104	1	2	
17th „ „	...	...	69½	107	1½	3	
18th „ „							
19th „ „	...	...	71½	110	2	3	
20th „ „							
21st „ „	...	...	73½	113	2	3	
22nd „ „							
23rd „ „	...	...	75½	116	2	3	
24th „ „							

Ran out of tank in night, 60 quarts in 19 hours; making a total of 176 quarts ran out of Tank in 31 hours.

This Tree was cut up into Sleepers; Copper very strong in heart as well as sides.

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DETAILS OF EXPERIMENT No. 6.

MEMEL.

TIME.	Time running quarter-pint of Liquid.		Quantity of Liquid ran out of Tree.	Quantity of Solution ran out of Tank.	Amount ran out of Tree in half-hour.	Amount ran out of Tank in half-hour.	REMARKS.
	Root end.	Top end.					
	m. s.	m. s.	Quarts.	Quarts.	Quarts.	Quarts.	Copper Solution came through bottom end in 5 minutes after pressure was turned on.
1st half-hour	...	...	4	8	4	8	
2nd „ „	...	...	8	13	4	5	
3rd „ „	...	...	12	18	4	5	
4th „ „	...	...	16	23	4	5	
5th „ „	...	...	20	28	4	5	
6th „ „	...	...	24	33	4	5	

Pressure kept on; 197 gallons ran out of Tank in 47 hours; making a total of 230 gallons ran out of Tank in 50 hours.

This piece of Timber cut up; Copper very strong all over.

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DETAILS OF EXPERIMENT No. 7.

BIRCH.

TIME.	Time running quarter-pint of Liquid.		Quantity of Liquid ran out of Tree.	Quantity of Solution ran out of Tank.	Amount ran out of Tree in half-hour.	Amount ran out of Tank in half-hour.	REMARKS.
	Root end.	Top end.	Quarts.	Quarts.	Quarts.	Quarts.	
							Began to run fast at each end immediately pressure was turned; faster at root end than top. 32 quarts of pure Sap ran out before Copper was perceptible. Copper at both ends in 25 minutes.
1st half-hour	Dropping from too many places to take time.		42	44	42	44	
2nd „ „			73	76	31	32	Copper strong at each end.
3rd „ „			101	104	28	28	
4th „ „			127	132	26	28	
5th „ „			145	152	18	20	Still running faster at root end than top.
6th „ „			158	168	13	16	
7th „ „			171	184	13	16	

This Tree cut up; Copper very strong all over.

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DETAILS OF EXPERIMENT No. 8.

SCOTCH FIR.

TIME.	Time running quarter-pint of Liquid. Root end.	Time running quarter-pint of Liquid. Top end.	Quantity of Liquid ran out of Tree.	Quantity of Solution ran out of Tank.	Amount ran out of Tree in half-hour.	Amount ran out of Tank in half-hour.	REMARKS.
	m. s.	m. s.	Quarts.	Quarts.	Quarts.	Quarts.	
							Began to drop slowly at root end in 19 minutes, at top end in 23 minutes. Pure Sap in both cases.
1st half-hour	only just dropping		...	4	...	4	
2nd " "	...	...	1	8	1	4	
3rd " "	2 19	2 53	4	12	3	4	
4th " "	2 13	2 42	7	16	3	4	
5th " "	2 9	2 31	11	21	4	5	
6th " "	2 11	2 29	15	25	4	4	
7th " "	2 19	2 38	18½	29	3½	4	
8th " "	2 17	2 37	22	33	3½	4	
9th " "	2 18	2 34	25½	37	3½	4	Sap pure as at first.
Ran 2 quarts in night			27½	total amount			
10th " "	2 45	3 15	29	42	1½	5	
11th " "	2 30	3 0	32	45	3	3	
12th " "	2 30	3 0	35	47	3	2	
13th " "	2 50	3 0	38	50	3	3	Copper just perceptible at each end.
14th " "	2 50	3 15	41	53	3	3	
15th " "	2 35	3 0	44	56	3	3	
16th " "	3 0	3 30	46½	58	2½	2	
17th " "	3 0	3 30	49	61	2½	3	
18th " "	3 0	3 45	51½	63	2½	2	
19th " "	3 15	4 0	53½	66	2	3	Copper coming out strong at both ends.

Pressure kept on. Ran out of Tree 64 quarts in 48½ hours, making a total of 130 quarts in 58 hours.

This Tree was cut up; Copper faintly perceptible all over.

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